Update on osteopathic medical concepts and the lymphatic system

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The osteopathic medical profession has long recognized the importance of the lymphatic system in maintaining health. A review of scientific studies shows much information on the mechanisms and importance of lymph circulation. Many osteopathic manipulative techniques designed to treat patients with tissue congestion are based on early research recognizing that lymph flow is influenced by myofascial compression. Osteopathic manipulative treatment of the diaphragm was substantiated when pressure differentials created by the thoracic diaphragm were shown to influence lymph flow. Current research demonstrates that autonomically mediated, intrinsic lymphatic contractility plays a significant role in lymph propulsion, supporting the use of osteopathic manipulative techniques directed at influencing the autonomic nervous system to improve lymphatic circulation. Although research provides an explanation of how osteopathic manipulative techniques influence the lymphatic system, experimentation to test the direct influence of manipulation on lymph circulation is needed. Clinical outcomes studies are also necessary to substantiate the clinical efficacy of osteopathic manipulative techniques.

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Homeostasis and the interrelationship of body systems are basic concepts in osteopathic medical theory. The lymphatic system has a critical role in both concepts. When lymphatic flow is impeded, tissues become edematous and metabolic waste products accumulate. These waste products adversely affect cellular activity, predisposing cells to dysfunction and disease. Pioneering members of the osteopathic medical profession developed manual techniques that help to mobilize stagnant fluids, quicken recovery from infections, and prevent potential disease-producing processes. These techniques, based on the anatomic and functional research of their time, focused on the fascia, diaphragm, and autonomic nervous system of the body. During the past 20 years, research involving the lymphatic system has provided much information and has clarified many traditional osteopathic medical concepts.

Mechanical basis of lymphatic technique

Anatomists as well as osteopathic physicians recognize fascia as the support structure for the lymphatic vessels. These vessels are thin-walled; their function is considered to depend on the stresses placed on them by surrounding tissues, particularly the myofascia.

Much research of the early to middle 20th century supported this perspective. In animal and human studies, there appeared to be no signs of lymph flow in a resting extremity; yet, when active or passive motion of that extremity occurred, a continuous stream of lymph was produced.[1(p519)] In 1952, Kubik[2(p519)] reported finding dilated ampullae throughout the lymph system. Those dilated ampullae situated intramuscularly were anchored in strong connective tissue. Kubik postulated that when the muscle contracted, the ampulla was compressed, propelling lymph. When the muscle relaxed, the connective tissue would draw apart the walls of the vessel, causing lymph to be sucked into that region. These external compressive forces create pressure gradients that move fluids centrifugally from regions of high to low pressure. Although multidirectional flow was observed in lymph capillaries, unidirectional flow toward the heart has been observed throughout the remaining lymphatic vessels. His-

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tologically, this flow toward the heart occurs because all lymphatic vessels other than capillaries contain valves to assure unidirectional flow.[3(p521)]

Other compressive forces affecting lymph flow have been recorded in the gastrointestinal and cardiovascular systems. In 1941, it was shown that an increase in peristalsis would increase intestinal and mesenteric lymph flow.[1(p520)] A mechanism explaining this event was described by Horstmann[4(p520)] in 1952. He reported the presence of thin-walled lymphatic vessels within the intestinal wall between the longitudinal and circular layers of musculature. Contraction of these muscles would significantly affect lymph flow. Most,[5(p523)] Lee,[6(p523)] and Beck[7(p523)] demonstrated how cardiac and arterial pulsations directly affected intrathoracic lymph flow. Other researchers demonstrated that peripheral arterial pulsations affect lymph flow.[8]

The pressure gradients created by movement of the body's diaphragms have been another consideration in lymphatic flow dynamics. In 1952, Fry and associates'[9] demonstration of intrapleural pressure changes coinciding with respiration, which was theorized by Yoffey and Courtice,[10(p172)] provides a mechanism whereby lymph in valved lymphatic vessels could be pumped to the upper mediastinum from the lower. Jossifow[11(pp521,522)] showed the effects of the diaphragm on the cisterna chyli. During exhalation, the cisterna is compressed, driving out its contents toward the heart. During inspiration, it dilates. Most[5(p521)] and Kubik[2(p522)] noted the respiratory cycle effect on the thoracic duct ampulla located at the duct's termination at the left subclavian or jugular vein. With inhalation, the ampulla would empty into the venous system. With exhalation, the ampulla would be refilled from the duct.

This research on the physiologic mechanisms creating lymphatic flow offers explanations for why various diseases respond to osteopathic manipulative intervention. It is postulated that the myofascial influences on lymph flow are used in soft tissue, lymphatic pump, and myofascial release techniques. One action of the pedal pump, a manual technique, is to cause repetitive tightening of the myofascia, thus promoting lymph flow. Another proposed mechanism of pedal pumping, as with thoracic pumping, is to improve diaphragmatically induced pressure gradients. Fascial restriction causing distortion of the lymphatic vessels and subsequent lymph stasis are treated with myofascial release techniques. Other manual techniques called *mesenteric lifts* are used to release myofascial restrictions affecting the visceral circulation. Zink[12,13] has reported manual techniques that maximize diaphragmatic motion and use direct compression over congested tissue to promote lymph flow.

Autonomic basis of lymphatic techniques

Until recently, few studies demonstrated intrinsic contractility of lymphatic vessels. This concept was generally disregarded by the American scientific community because their experiments were unable to reproduce these observations. Johnston,[14] a leading lymphologist, noted that it was not until experimental techniques were refined that studies consistently demonstrated the intrinsic contractility of lymphatic vessels.

Knowledge of smooth muscle elements and autonomic nerve fibers in the walls of lymphatic vessels is long-standing.[1(p524)] The first report of rhythmic contractility of lymphatic vessel segments in birds, dogs, and horses occurred in 1774.[15] In 1869 and again in 1910, researchers witnessed contraction of lymphatic vessels in guinea pigs at a rate of 8 to 10 per minute.[10(p167)] In 1949 to 1950, Rusznyák and coworkers[1(p525)] placed an electrode on an isolated lower portion of the left sympathetic trunk of a dog. When radiopaque material was injected into lymphatic vessels of both hind legs, serial x-ray films demonstrated normal lymph flow in both, but when the electrode stimulated the trunk, essentially no lymph flow occurred in the left hind leg. In an unanesthetized sheep in 1965, Hall and coworkers[16] demonstrated movements in many vessels, with rates varying from 1 to 30 per minute, unrelated to respirations. It also appeared that the effect of inherent rhythmic contractility was of greater importance to lymph flow than respiratory (diaphragmatic) movement in standing sheep at rest. In vitro studies of bovine mesenteric lymphatic vessels during the 1970s demonstrated spontaneous vessel contractions two to three times per minute. The contractions, which were sharp, were followed by abrupt relaxation and long diastolic interval. Norepinephrine increased the rate of contractions yet reduced their strength. Acetylcholine did not affect the contractions.[17]

In the late 1950s and early 1960s, researchers first demonstrated spontaneous lymphatic contractions in humans.[1(p545)] Kinmonth and Taylor[18] showed that the thoracic duct contracted once every 10 to 15 seconds. In 1963, photographs of a contracted and relaxed peripheral lymphatic vessel in a person undergoing lymphangiography were published.[19] In 1979, five healthy, upright, motionless men had lymphatic vessels in their legs cannulated. Rhythmic pulse waves were found with different frequency and amplitude, duration from 6 to 8 seconds, and mean pressure steadily increasing to 15 mm Hg to 20 mm Hg. These pulse waves were asynchronous with respiration or leg movement.[20] These facts suggested that spontaneous, intrinsic rhythmic lymphatic contractions may be a major impetus in lymph flow.

Although most current osteopathic medical teaching focuses on the extrinsic influences on lymph flow, clinical observations by osteopathic physicians in classic osteopathic medical writings demonstrate recognition of intrinsic contractility of the lymphatic vessels. A.T. Still recognized in *Philosophy and Mechanical Principles of Osteopathy* that "finer nerves dwell with the lymphatics than even with the eye." In Millard's *Applied Anatomy of the Lymphatics*,[21] Still's view on innervation of the lymphatics is quoted:

> Dr. Still points out [that a] spinal lesion [can affect]... the full length of the thoracic duct, acting through the various spinal sympathetic connections, splanchnics, etc. He mentions especially [the] lesion at the 4th dorsal, which he calls a center for nutrition, and at the 7th cervical, opposite which the duct ends. He has called attention to lesion[s] in the upper dorsal region, just below the cervical, giving rise to the growth of a fleshy cushion, a condition of affairs that seems to influence the lymphatic system and cause deposition of fat. He also works high in the cervical region, opposite the transverse processes of the vertebrae, for nerves controlling the caliber of the duct.[21]

Lymphatic physiology

The regulation of the intrinsic contractility of the lymphatic system is based on transmural distention of the vessel walls and neural and humoral mediators.[22]

A lymphangion is a segment of vessel between two valves. When it distends beyond a certain threshold, a contraction (systole) occurs. The contraction will last usually between 0.8 and 1.0 second. The vessel then relaxes (diastole) and remains refractory to further stimulation for a period of time. A usual diastolic interval will be 2 to 3 seconds. A cycle will generally occur 10 to 18 times a minute. Usually, the contraction of one lymphangion will stimulate proximal lymphangions to contract sequentially, thus moving fluid toward the thoracic duct. As the distention of a vessel increases, the frequency and amplitude of contractions increase up to a certain point. At that point, the system becomes overloaded and the rate and strength of contractions decrease.[22] These features indicate a self-regulation mechanism that responds to local demands.

Several humoral mediators including epinephrine, norepinephrine, histamine, serotonin, prostaglandins, acetylcholine, and dopamine modulate lymphatic smooth muscle contractions. Catecholamines enhance lymphatic contractility, whereas adrenergic blocking agents inhibit contractions. Serotonin, a potent stimulator of lymph vessel contraction, actually causes spasm, essentially stopping flow. Various prostaglandins (E_1, E_2, F_2), potent vasodilators, inhibit lymphatic motility, but $PGF_{2\alpha}$, PGA_2 and PGB_2, other prostaglandin derivatives, increase the frequency and amplitude of contractions. Even reduction of calcium affects flow by increasing the frequency yet decreasing the force of contractions.[22] The presence of an endotoxin has an inhibitory effect that may encourage the edema found with sepsis and infectious inflammation.[23]

A neurologic control can be assumed in view of the response of the lymphatic vessels to shock and carotid occlusion. Two studies have shown that major blood loss enhances lymphatic contractility.[24,25] Because distention is not present to cause a contraction, neurologic or humoral input are possible stimulating sources. Direct nerve stimulation in situ can cause contraction or spasm. Bilateral carotid occlusion also results in increased lymphatic perfusion.[24]

Obviously, the physiology of the lymphatic system is quite complex. Research has only begun to demonstrate the many factors that influence lymphatic flow. The extrinsic compression of the myofascia on the lymphatics has been the focus of many manipulative techniques. Current research supports such techniques on a conceptual basis. Studies now consistently demonstrate contractility in lymphatic vessels. This intrinsic pumping has been shown to be under autonomic control, modulated locally by soft tissue chemicals and systemically produced hormones. Currently, it appears that intrinsic contractions may have more influence on lymph flow than extrinsic forces. This perspective provides support for the classical goal of manipulation: to promote circulation by influencing the tone of the autonomic nervous system. A successful treatment will improve not only arterial and venous tone but also lymphatic contractility. Manual techniques that compress lymph channels not only help lymph flow directly, but also remove local substances that are inhibiting vessel contractility. Manipulation, focused to vetebral segments and paraspinal tissues at those levels where the spinal nerves and sympathetic chain ganglia innervate a region of lymphatic congestion, can be utilized to possibly enhance lymphatic flow.

As scientists continue their pursuit of further understanding, it is important that traditional concepts are regularly evaluated in light of new data. In this circumstance, Downing's[20(p130)] statement in 1922 remains true today: "... we are justified in accepting the vasomotor control of the lymph vessels, subject, however, to the mechanical influences ...."

For those who accept and apply this osteopathic rationale, further questions can be pondered. What is the relationship of lymphatic contractility to the cranial rhythmic impulse (CRI)? Could lymphatic contractility be causing the fascial impulse palpated through the body? What implication does this have for osteopathic physicians in treating the chronically fatigued patient, as many of these patients have a diminished CRI?

Many people may criticize the osteopathic manipulative approach emphasizing lymph flow. They may state that the scientific support noted is only hypothetical because there has not been direct research evaluating the effect of manipulation on lymph flow. Nor has there been research documenting that manipulation directed at treating the lymphatic system helps to improve a person's health. Although a few studies had been reported in osteopathic medical literataure beginning to document a clinical efficacy of lymphatic techniques[26-28] and delineating the actual mechanisms for certain manipulative techniques,[29-31] they are in need of replication with a greater number of participants. In this time of intense scrutiny of the healthcare system, it is critical that such research is performed and appropriately reported. Such osteopathic medical research may be facilitated by collaboration with current lymphologists and use of current research designs and equipment for analyzing the lymphatic system.

Comment

Based on a century of research, information on the mechanisms of lymphatic circulation provides the rationale for using manipulation to support homeostasis. Such understanding needs to be emphasized during osteopathic medical training so that manipulation is integrated into daily patient care. Research evaluating the effects of manipulation on lymph flow and its role in facilitating recovery needs to become a priority for centers of osteopathic medical research.

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